Chapter 2
Reservoir Purposes

2-1. Congressional Authorizations

a. Authorization of purposes. The United States Congress authorizes the purposes served by U.S. Army Corps of Engineers reservoirs at the time the authorizing legislation is passed. Congress commonly authorizes a project "substantially in accordance with the recommendations of the Chief of Engineers," as detailed in a separate congressional document. Later, additional purposes are sometimes added, deleted, or original purposes modified, by subsequent congressional action. When the original purposes are not seriously affected, or structural or operational changes are not major, modifications may be made by the Chief of Engineers (Water Supply Act 1958).

b. General legislation. Congress also passes general legislation that applies to many projects. The 1944 Flood Control Act, for example, authorizes recreational facilities at water resource development projects. This authority has made recreation a significant purpose at many Corps reservoirs. Similar general legislation has been passed to enhance and promote fish and wildlife (1958) and wetlands (1976). The Water Resource Development Act of 1976 authorizes the Chief of Engineers, under certain conditions, to plan and establish wetland areas as part of an authorized water resource development project. A chronology of the congressional legislation authorizing various purposes and programs is shown in Figure 2-1 (USACE 1989).

c. Additional authorization. Figure 2-1 illustrates how additional authorizations have increased the number of purposes for which the Corps is responsible both in planning and managing water resource development projects. The first authorizations were principally for navigation, hydroelectric power, and flood control. Later authorizations covered a variety of conservation purposes and programs. During drought when there is a water shortage, all purposes compete for available water and are affected by the shortage. The more purposes and programs

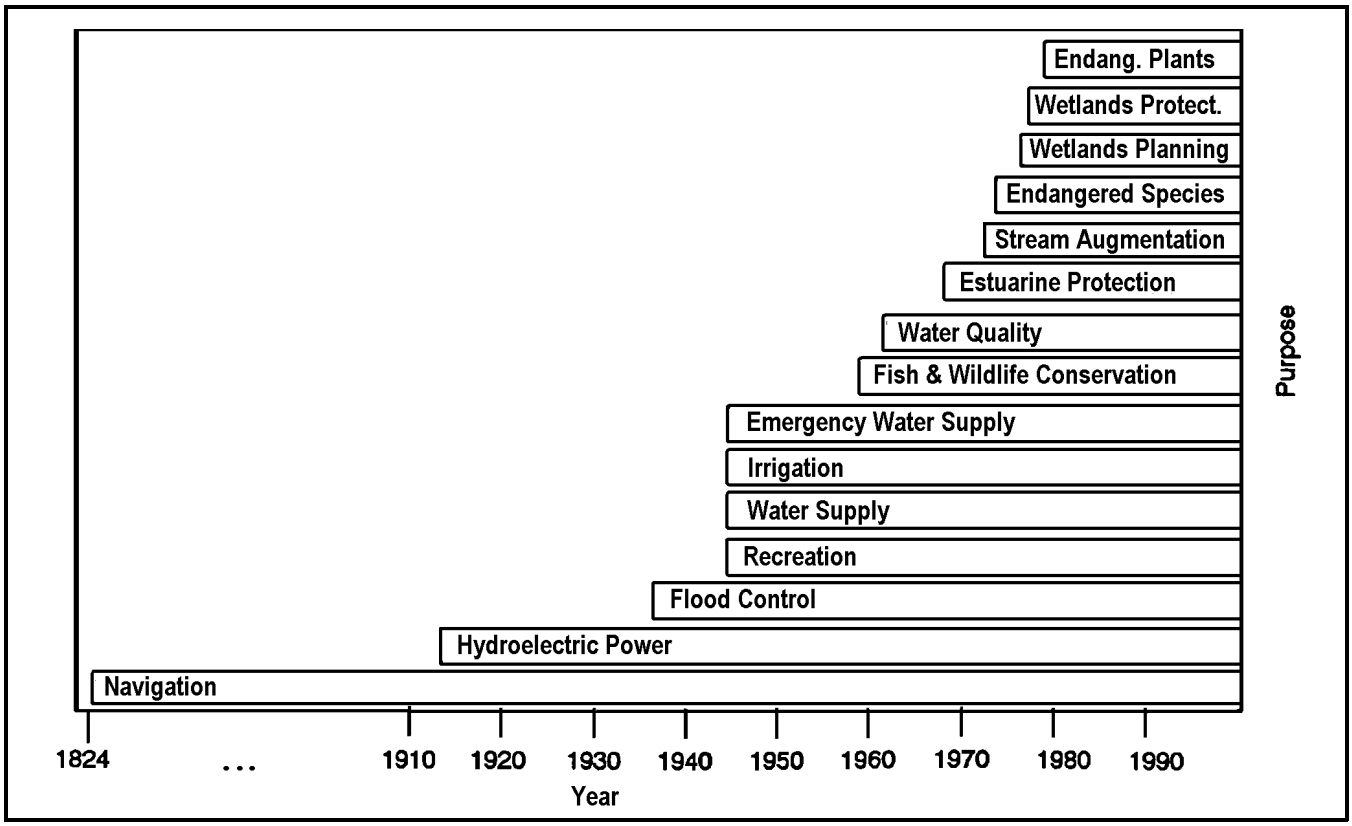

Figure 2-1. Purposes and programs authorized by Congress

there are to serve, the greater the potential for conflict, and the more complex the task of managing existing supplies. “Authorized and Operating Purposes of Corps of Engineers' Reservoirs” (USACE 1992) lists the purposes for which Corps operated reservoirs were authorized and are operated.

2-2. Reservoir Purposes

a. Storage capacity. A cross section of a typical reservoir is shown in Figure 2-2. The storage capacity is divided into three zones: exclusive, multiple-purpose, and inactive. While each Corps reservoir is unique both in its allocation of storage space and in its operation, the division of storage illustrated by Figure 2-2 is common.

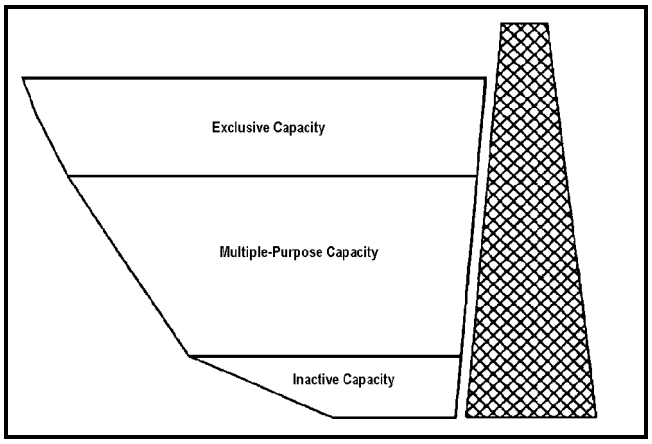

Figure 2-2. Typical storage allocation in reservoirs

b. Exclusive capacity. The exclusive space is reserved for use by a single purpose. Usually this is flood control, although navigation and hydroelectric power have exclusive space in some reservoirs. The exclusive capacity reserved for flood control is normally empty. Some reservoirs with exclusive flood control space have no multiple-purpose pool but have a nominal inactive pool that attracts recreational use. Recreational use is also common on pools originally established exclusively for navigation.

c. Multiple-purpose capacity. Multiple-purpose storage serves a variety of purposes. These purposes include both seasonal flood control storage, often in addition to exclusive storage, and conservation. Conservation purposes include: navigation, hydroelectric power, water supply, irrigation, fish and wildlife, recreation, and water quality. Other conservation purposes such as wetlands, groundwater supply and endangered species, while not included in this manual, are nonetheless important in water control management.

d. Inactive capacity. The inactive space is commonly used to maintain a minimum pool and for sediment storage. Sediment storage may affect all levels of the reservoir storage. Also, the inactive capacity may sometimes be used during drought when it can provide limited but important storage for water supply, irrigation, recreation, fish and wildlife, and water quality.

e. Storage space allocation. Reservoir storage space may not be allocated to specific conservation purposes. Rather, reservoir releases can serve several purposes. However, the amount of water needed to serve each purpose varies. During drought, with limited multiple-purpose storage available, the purposes requiring greater releases begin to compete with purposes requiring less. For example, if the greater releases are not made, the storage would last longer for the purposes served by the lesser releases.

f. General information. A brief description of project purposes is presented below. Additional detail and a discussion of reservoir operating procedures may be found in EM 1110-2-3600, from which the following sections are excerpts.

2-3. Flood Control

a. Utilizing storage space. Reservoirs are designed to minimize downstream flooding by storing a portion or sometimes the entire runoff from minor or moderate flood events. Each reservoir's water control plan defines the goals of regulation. Usually, a compromise is achieved to best utilize the storage space to reduce flooding from both major and minor flood events. In special circumstances where reservoir inflows can be forecast several days or weeks in advance (for example, when the runoff occurs from snowmelt), for the best utilization of storage space, the degree of control for a particular flood event may be determined on the basis of forecasts. When runoff is seasonal, the amount of designated flood control storage space may be varied seasonally to better utilize the reservoirs for multiple-purpose regulation.

b. Releases. Flood control releases are based upon the overall objectives to limit the discharges at the downstream control points to predetermined damage levels. The regulation must consider the travel times caused by storage effects in the river system and the local inflows between the reservoir and downstream control points.

c. Intervening tributary and downstream damage areas. A multiple-reservoir system is generally regulated for flood control to provide flood protection both in intervening tributary areas and at downstream main stem damage areas. The extent of reservoir regulation required for protecting these areas depends on local conditions of flood damage, uncontrolled tributary drainage, reservoir storage capacity, and the volume and time distribution of reservoir inflows. Either the upstream or downstream requirements may govern the reservoir regulation, and usually the optimum regulation is based on the combination of the two.

d. Coordinated reservoir regulation. Water control with a system of reservoirs can incorporate the concept of a balanced reservoir regulation, with regard to filling the reservoirs in proportion to each reservoir's flood control capability, while also considering expected inflows and downstream channel capacities. Evacuation of flood water stored in a reservoir system must also be accomplished on a coordinated basis. Each reservoir in the system is drawn down as quickly as possible, considering conditions at control points, to provide space for controlling future floods. The objectives for withdrawal of water in the various zones of reservoir storage are determined to minimize the risk of encroaching into the flood control storage and to meet other project requirements. Sometimes the lower portion of the flood control pool must be evacuated slower to transition to a lower flow to minimize bank caving and allow channel recovery.

2-4. Navigation

a. Navigational requirements. Problems related to the management of water for navigation use vary widely among river basins and types of developments. Control structures at dams, or other facilities where navigation is one of the project purposes, must be regulated to provide required water flows and/or to maintain project navigation depths. Navigational requirements must be integrated with other water uses in multiple-purpose water resource systems. In the regulation of dams and reservoirs, the navigational requirements involve controlling water levels in the reservoirs and at downstream locations, and providing the quantity of water necessary for the operation of locks. There also may be navigational constraints in the regulation of dams and reservoirs with regard to rates of change of water surface elevations and outflows. There are numerous special navigational considerations that may involve water control, such as ice, undesirable currents and water flow patterns, emergency precautions, boating events, and launchings.

b. Waterflow requirements. Navigation locks located at dams on major rivers generally have sufficient water from instream flows to supply lockage water flow requirements. Navigation requirements for downstream use in open river channels may require larger quantities of water over a long period of time (from several months to a year), to maintain water levels for boat or barge transportation. Usually, water released from reservoirs for navigation is also used for other purposes, such as hydroelectric power, low-flow augmentation, water quality, enhancement of fish and wildlife, and recreation. Seasonal or annual water management plans are prepared which define the use of water for navigation. The amount of stored water to be released depends on the conditions of water storage in the reservoir system and downstream requirements or goals for low-flow augmentation, as well as factors related to all uses of the water in storage.

c. Using water for lockage. Navigational constraints are also important for short-term regulation of projects to meet all requirements. In some rivers, supply of water for lockage is a significant problem, particularly during periods of low flow or droughts. The use of water for lockage is generally given priority over hydropower or irrigation usages. However, this is dependent on the storage allocated to each purpose. In critical low-water periods, a curtailment of water use for lockage may be instituted by restricting the number of locks used, thereby conserving the utilization of water through a more efficient use of the navigation system. Water requirements for navigation canals are sometimes based on lockage and instream flows as necessary to preserve water quality in the canal.

2-5. Hydroelectric Power

a. Reservoir project categories. Reservoir projects which incorporate hydropower generally fall into two distinct categories: storage reservoirs which have sufficient capacity to regulate streamflow on a seasonal basis and run-of-river projects where storage capacity is minor relative to the volume of flow. Most storage projects are multiple-purpose. Normally, the upstream reservoirs include provisions for power production at the site, as well as for release of water for downstream control. Run-of-river hydropower plants are usually developed in connection with navigation projects.

b. Integration and control of a power system. Integration and control of a major power system involving hydropower resources is generally accomplished by a centralized power dispatching facility. This facility

contains the equipment to monitor the entire power system operation, including individual plant generation, substation operation, transmission line operation, power loads and requirements by individual utilities and other bulk power users, and all factors related to the electrical system control for real-time operation. The dispatching center is manned on a continuous basis, and operations monitor and control the flow of power through the system, rectify outages, and perform all the necessary steps to ensure the continuity of power system operation in meeting system loads.

c. Regulation of a hydropower system. Regulation of hydropower systems involves two levels of control: scheduling and dispatching. The scheduling function is performed by schedulers who analyze daily requirements for meeting power loads and resources and all other project requirements. Schedules are prepared and thoroughly coordinated to meet water and power requirements of the system as a whole. Projections of system regulation, which indicate the expected physical operation of individual plants and the system as a whole, are prepared for one to five days in advance. These projections are updated on a daily or more frequent basis to reflect the continuously changing power and water requirements.

2-6. Irrigation

a. Irrigation diversion requirements. Irrigation water diverted from reservoirs, diversion dams, or natural river channels is controlled to meet the water duty requirements. The requirements vary seasonally, and in most irrigated areas in the western United States, the agricultural growing season begins in the spring months. The diversion requirements gradually increase as the summer progresses, reaching their maximum amounts in July or August. They then recede to relatively low amounts by late summer. By the end of the growing season, irrigation diversions are terminated, except for minor amounts of water that may be necessary for domestic use, stock water, or other purposes.

b. Irrigation as project purpose. Corps of Engineers' reservoir projects have been authorized and operated primarily for flood control, navigation, and hydroelectric power. However, several major Corps of Engineers multiple-purpose reservoir projects include irrigation as a project purpose. Usually, water for irrigation is supplied from reservoir storage to augment the natural streamflow as required to meet irrigation demands in downstream areas. In some cases, water is diverted from the reservoir by gravity through outlet facilities at the dam which feed directly into irrigation canals. At some of the run-of-river power or navigation projects, water is pumped directly from the reservoir for irrigation purposes.

c. Meeting irrigation demands. The general mode for regulation of reservoirs to meet irrigation demands is to capture all runoff in excess of minimum flow demands and water rights during the spring and early summer. This usually results in refilling the reservoirs prior to the irrigation demand season. The water is held in storage until the natural flow recedes to the point where it is no longer of sufficient quantity to meet all demands for downstream irrigation. At that time, the release of stored water from reservoirs is begun and continued on a demand basis until the end of the growing season (usually September or October). During the winter, projects release water as required for instream flows, stock water, or other project purposes.

2-7. Municipal and Industrial Water Supply

a. Municipal and industrial use. Regulation of reservoirs for municipal and industrial (M&I) water supply is performed in accordance with contractual arrangements. Storage rights of the user are defined in terms of acre-feet of stored water and/or the use of storage space between fixed limits of reservoir levels. The amount of storage space is adjusted to account for change in the total reservoir capacity that is caused by sediment deposits. The user has the right to withdraw water from the lake or to order releases to be made through the outlet works. This is subject to Federal restrictions with regard to overall regulation of the project and to the extent of available storage space.

b. Temporary withdrawal. In times of drought, special considerations may guide the regulation of projects with regard to water supply. Adequate authority to permit temporary withdrawal of water from Corps projects is contained in 31 U.S.C. 483a (HEC 1990e). Such withdrawal requires a fee that is sufficient to recapture lost project revenues, and a proportionate share of operation, maintenance, and major replacement expenses.

2-8. Water Quality

a. Goal and objective. Water quality encompasses the physical, chemical, and biological characteristics of water and the abiotic and biotic interrelationships. The quality of the water and the aquatic environment is significantly affected by management practices employed by the water control manager. Water quality control is an authorized purpose at many Corps of Engineers reservoirs. However, even if not an authorized project purpose, water quality is an integral consideration during all phases of a project's life, from planning through operation. The minimum goal is to meet State and Federal water quality

standards in effect for the lakes and tailwaters. The operating objective is to maximize beneficial uses of the resources through enhancement and nondegradation of water quality.

b. Release requirements. Water quality releases for downstream control have both qualitative and quantitative requirements. The quality aspects relate to Corps' policy and objectives to meet state water quality standards, maintain present water quality where standards are exceeded, and maintain an acceptable tailwater habitat for aquatic life. The Corps has responsibility for the quality of water discharged from its projects. One of the most important measures of quality is quantity. At many projects authorized for water quality control, a minimum flow at some downstream control point is the primary water quality objective. Other common objectives include temperature, dissolved oxygen, and turbidity targets at downstream locations.

c. Coordinated regulation. Coordinated regulation of multiple reservoirs in a river basin is required to maximize benefits beyond those achievable with individual project regulation. System regulation for quantitative aspects, such as flood control and hydropower generation, is a widely accepted and established practice, and the same principle applies to water quality concerns. Water quality maintenance and enhancements may be possible through coordinated system regulation. This applies to all facets of quality from the readily visible quantity aspect to traditional concerns such as water temperature and dissolved oxygen content.

d. System regulation. System regulation for water quality is of most value during low-flow periods when available water must be used with greatest efficiency to avoid degrading lake or river quality. Seasonal water control plans are formulated based on current and forecasted basin hydrologic, meteorologic and quality conditions, reservoir status, quality objectives and knowledge of water quality characteristics of component parts of the system. Required flows and qualities are then apportioned to the individual projects, resulting in a quantitatively and qualitatively balanced system. Computer programs capable of simulating reservoir system regulation for water quality provide useful tools for deriving and evaluating water control alternatives.

2-9. Fish and Wildlife

Project regulation can influence fisheries both in the reservoir pool and downstream. One of the most readily observable influences of reservoir regulation is reservoir pool fluctuation. Periodic fluctuations in reservoir water levels present both problems and opportunities to the water control manager with regard to fishery management. The seasonal fluctuation that occurs at many flood control reservoirs, and the daily fluctuations that occur with hydropower operation often result in the elimination of shoreline vegetation and subsequent shoreline erosion, water quality degradation and loss of habitat. Adverse impacts of water level fluctuations also include loss of shoreline shelter and physical disruption of spawning and nests.

2-10. Recreation

a. Reservoir level. Recreational use of the reservoirs may extend throughout the entire year. Under most circumstances, the optimum recreational use of reservoirs would require that the reservoir levels be at or near full conservation pool during the recreation season. The degree to which this objective can be met varies widely, depending upon the regional characteristics of water supply, runoff, and the basic objectives of water regulation for the various project purposes. Facilities constructed to enhance the recreational use of reservoirs may be designed to be operable under the planned reservoir regulation guide curves on water control diagrams, which reflect the ranges of reservoir levels that are to be expected during the recreational season.

b. Downstream river levels. In addition to the seasonal regulation of reservoir levels for recreation, regulation of project outflows may encompass requirements for specific regulation criteria to enhance the use of the rivers downstream from the projects, as well as to ensure the safety of the general public. The Corps has the responsibility to regulate projects in a manner to maintain or enhance the recreational use of the rivers below projects to the extent possible (i.e., without significantly affecting the project function for authorized purposes). During the peak recreation season, streamflows are regulated to ensure the safety of the public who may be engaged in water related activities, including boating, swimming, fishing, rafting, and river drifting. Also, the aesthetics of the rivers may be enhanced by augmenting streamflows during the low-water period. Water requirements for maintaining or enhancing the recreational use of rivers are usually much smaller than other major project functional uses. Nevertheless, it is desirable to include specific goals to enhance recreation in downstream rivers in the water control plan. The goals may be minimum project outflows or augmented streamflows at times of special need for boating or fishing. Of special importance is minimizing any danger that might result from changing conditions of outflows which would cause unexpected rise or fall in river levels. Also, river drifting is becoming an important

recreational use of rivers, and in some cases it may be possible to enhance the conditions of stream flow for relatively short periods of time for this purpose.

2-11. Water Management Goals and Objectives

a. Water management. ER 1110-2-240 paragraph 6, defines the goals and objectives for water regulation by the Corps. Basically, the objective is to conform with specific provisions of the project authorizing legislation and water management criteria defined in Corps of Engineers reports prepared in the planning and design of the project or system. Beyond this, the goals for water management will include the provisions, as set forth in any applicable authorities, established project construction, and all applicable Congressional Acts and Executive Orders relating to operations of Federal facilities.

b. Water control systems management. EM 1110-2-3600 provides guidance on water control plans and project management. A general prime requirement in project regulation is the safety of users of the facilities and the general public, both at the project and at downstream locations. The development of water control plans and the scheduling of reservoir releases must be coordinated with appropriate agencies, or entities, as necessary to meet commitments made during the planning and design of the project. Additionally, water control plans must be reviewed and adjusted, when possible, to meet changing local conditions.

c. Regional management. Regional water management should consider the interaction of surface-groundwater resources. HEC Research Document 32 provides examples for several regions in the United States (HEC 1991c).